

MAPPING THE POTENTIAL FOR DECENTRALIZED ENERGY GENERATION BASED ON RES IN WESTERN BALKANS

by

Daniel R. SCHNEIDER, Neven DUIĆ, Igor RAGUZIN, Željko BOGDAN, Marko BAN, Borislav GRUBOR, Predrag STEFANOVIĆ, Dragoljub DAKIĆ, Branislav REPIĆ, Žarko STEVANOVIĆ, Ana ŽBOGAR, Maja STUDOVIĆ, Stevan NEMODA, Nikola OKA, Dejan DJUROVIĆ, Nikola KADIĆ, Vukman BAKIĆ, Srdjan BELOŠEVIĆ, Aleksandar ERIĆ, Rastko MLADENOVIĆ, Milijana PAPRIKA, Nijaz DELALIĆ, Alija LEKIĆ, Rasim BAJRAMOVIĆ, Armin TESKEREDŽIĆ, Izet SMAJEVIĆ, Ejub DŽAFEROVIĆ, Fajik BEGIĆ, Haris LULIĆ, Sadjit METOVIĆ, Semir PETROVIĆ, Adnan DJUGUM, Džana KADRIĆ, Nihad HODŽIĆ, Fahrudin KULIĆ, Anes KAZAGIĆ, and Admir GAFIĆ

Original scientific paper

UDC: 621.316:620.97

BIBLID: 0354-9836, 11 (2007), 3, 7-26

Although the countries of the Western Balkans are mostly electrified, there are still regions which do not have access to the electricity network or where the network capacity is insufficient. For the most part such areas are under special care of the state (i. e. underdeveloped, devastated by war, depopulated), on islands or in mountainous regions. Since the decentralized energy generation covers a broad range of technologies, including many renewable energy technologies that provide small-scale power at sites close to the users, such concept could be of interest for these locations. This paper identifies the areas in Western Balkans where such systems could be applied. Consideration is given to geographical locations as well as possible applications. Wind, hydro, solar photovoltaic, and biomass conversion systems were taken into consideration. Since the renewable energy sources data for Western Balkans region are rather scarce, the intention was to give a survey of the present situation and an estimate of future potential for decentralized energy generation based on renewable energy sources. The decentralized energy generation based on renewable energy sources in Western Balkans will find its niche easier for the users that will produce electricity for their own needs and for the users located in remote rural areas (off-grid applications).

Key words: *decentralized power production, distributed energy generation, renewable energy sources, wind, biomass, solar, hydro*

Introduction

The Western Balkans region – here including Albania, Bosnia and Herzegovina (B&H), Croatia, Kosovo/UN interim administration mission in Kosovo (UNMIK), Macedonia, Montenegro, and Serbia – is recovering from over a decade of conflict and insta-

bility, which are result of the dissolution of the former Yugoslavia. As the region stabilizes, the Balkans will play an important role not only as a transit centre for gas and electricity as well as for the oil exports from the Russian and Caspian sea region, but may also become a part of a new decentralised energy generation (DEG) system of the wider EU.

Recognizing potential benefits, and as part of a wider movement to deeper regional integration, the governments of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo/UNMIK, Macedonia, Montenegro, Romania, and Serbia signed the Athens Memorandum (2002, revised in 2003, entered into force on July 1st, 2006), in which it was agreed to establish a South East Europe Regional Electricity Market (SEE-REM) now known as the Energy Community of SEE. Based on that agreement as well as an adoption of the EU Directives 2003/54/EC and 2003/55/EC on the internal market in electricity and natural gas, the gradual liberalisation of energy markets similar to the EU liberalisation is foreseen. Table 1 shows the current state of market opening in Western Balkans (WB) [1, 2].

Table 1. Market opening in WB countries

Country	Market opening	Eligibility threshold	Unbundling	
			TSO ¹	DSO ²
Albania	8%	40 GWh/year	Legal	None
Bosnia and Herzegovina	33%	10 GWh/year (1 GWh/year from January 2008)	Legal	None
Croatia	25%	9 GWh/year (for non-residential consumers from July 2007)	Legal	Legal
Kosovo/UNMIK	0%	Eligible consumers (four) connected at 110 kV and over	Man. ³	None
Macedonia	28%	20 GWh/year and connected to high voltage (threshold shall be reduced in 2007)	Legal	None
Montenegro	17%	Direct customers (110 kV) as well as EPCG ⁴ (for tariff customers) meet about one third of their electricity demand through imports	Man.	None
Serbia	16%	25 GWh/year at all metering points of one customer	Legal	None

1 – transmission system operator; 2 – distribution system operator; 3 – management; 4 – Electric power generation company of Montenegro

Although all WB countries have the primary energy legislation (here covering electricity and the establishment of the applicable regulatory authority), some of the sec-

Table 2. Legislation

Country	Primary legislation	Secondary legislation	Draft legislation	Regulatory authority
Albania	Yes	Yes	Yes	Yes
Bosnia and Herzegovina (B&H)	Yes 3 electricity laws; 1 in B&H and 1 for each entity	No	Yes	Yes
Croatia	Yes	Yes	Yes	Yes
Kosovo/UNMIK	Yes	No	Yes	Yes
Macedonia	Yes	Yes	No	Yes
Montenegro	Yes	No	Yes	Yes
Serbia	Yes	Yes	Pending; various pieces of secondary legislation, pursuant to the new energy law	Yes































































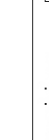

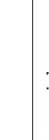

ondary legislation is still missing (tab. 2) [3, 4]. The Article 20 of the Treaty establishing the Energy Community says that each contracting Party shall provide to the European Commission within one year of the date of entry into force of the Treaty: (1) a plan to implement Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources (RES) in the internal electricity market and (2) a plan to implement Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport. In another article (Article 35) of the Treaty is written that the Energy Community may adopt measures to foster development in the areas of renewable energy sources and energy efficiency, taking account of their advantages for security of supply, environment protection, social cohesion, and regional development. Tables 3 and 4 give the current status of transposition and implementation of Directive 2001/77/EC [3-5].


Map of DEG potential in Western Balkans

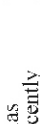
As a result of restoring order and stability in the region of WB, business and industrial activities have been intensified resulting in greater electricity consumption. In some countries there is not enough capacity to meet those greater needs (*e. g.* several years of power reductions in Albania [6]) while the other countries' power generation capacities are stretched to the limits (*e. g.* Croatia or Macedonia [7]).

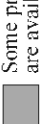
Although the countries of the WB are greatly electrified, there are still regions which do not have access to the electricity network or where the network capacity is in-

Table 3. Benchmarking – Renewable energy

Country	Renewable energy					
	Transposition of 2001/77/EC	Implementation plan for 2001/77/EC				Implementation plan for 2003/30/EC
		Indicative targets	Support scheme	Certificate of origin	Authorisation procedure	Grid code provisions
Albania						
Bosnia and Herzegovina						
Bulgaria						
Croatia						
The former Yugoslav Republic of Macedonia						
Montenegro						
Romania						
Serbia						
UN interim administration mission in Kosovo						
Turkey						
Regional perspective						

 Process has started recently

 Some provisions are available

 Some provisions are missing


 All provisions are available

Table 4. Renewable energy – legislative basis, 2001/77/EC implementation plan and specific characteristics

Renewable energy			
Country	Legislative basis	Plan for the implementation of the 2001/77/EC	Specific characteristics in the sector of renewable sources
Albania	<p>Albania has legislation on energy efficiency, but has not the one related to the renewable sources;</p> <p>The Law on Energy Efficiency has been enforced in April 2005 (drafted by Pierce Atwood) treating energy auditing, energy labelling, two-year energy efficiency planning and energy efficiency fund (not operable yet);</p>	<p>The Law on Power Sector has a very few provisions related to future development of RES. One of them states that when building new conventional thermal power plants, it is necessary to use 2% of RES;</p> <p>The Law on Power Sector gives provisions for small power plants which need simplified rules and procedures with respect to their treatment in the Grid Code and other documents;</p>	<p>The National Energy Strategy from 2004 contains several sections on the RES, mostly on the small hydro power plants, wind, and solar energy (not much on biomass). There is a KfW promoted program through the National Agency for Energy at the level of 9 millions for further development of the RES (3.5 million), energy efficiency (3.5 millions), and technical assistance for implementing agencies (2 millions);</p> <p>The Albania – EU Energy Efficiency Centre has been established in 1993 (4 experts, 1 economist, 2 support staff) as a consequence of taking obligations from the Energy Charter Treaty. The Centre has become a self-financed body after 2001 dealing with energy auditing, pre-feasibility and feasibility studies, training. It also participates in a variety of research and development programs financed by the EU in the fields of renewable sources (wind, solar, PV, biomass). The Centre intends to correlate these programs to the governmental programs directed towards the vulnerable consumers living in distant and rural areas;</p>
Bosnia and Herzegovina	<p>It is expected that the sector of renewable sources will be arranged through the set of by-laws;</p> <p>The Energy Charter Treaty has been signed and accordingly the state has committed itself to develop appropriate energy efficiency strategy;</p>	<p>Requests for construction of hydro power plants come in large numbers, but there is no relevant framework for their actual realisation;</p> <p>RES network connection is not resolved yet. The ISO expects to come up with the framework solution based on the first case that would appear. It intends to apply an affirmative attitude towards investors;</p>	<p>There are no specialised agencies neither for energy efficiency nor for renewable sources;</p> <p>Due to use of gas in cogeneration, the efficiency is rather low and several studies have shown so far that a lot of progress can be made in this area;</p> <p>Price for electricity generated in small hydro power plants is considered to be very low, and it prevents investors from further plant construction activities. A request is submitted to the regulatory commission to analyse this price thoroughly;</p> <p>However, there are several ongoing project activities, but more on an ad hoc basis and in a sporadic way. Systematic approach does not exist and institutionalisation in this field is needed to avoid development on a voluntary case-by-case basis;</p>

Table 4 (Continuation)

Renewable energy			
Country	Legislative basis	Plan for the implementation of the 2001/77/EC	Specific characteristics in the sector of renewable sources
Bulgaria	<p>Electricity production from RES: Energy Act and Regulation for Certification of Origin;</p> <p>Biofuels for transport: A law being drafted in the context of RES will cover biofuels for transport;</p>	The Directive is transposed;	<p>The Energy Act states that the Council of Ministers will approve a National indicative target of electricity produced from RES for a 10 year period. A National indicative target of 11% share of electricity from RES in the gross internal consumption by 2010 is defined in the Technical adaptations to the Bulgarian Accession Treaty concerning Directive 2001/77/EC on the promotion of electricity produced from RES in the internal electricity market;</p> <p>RES electricity production is promoted through feed-in tariffs which are established by the Energy Regulator. The Energy Act states that the preferential prices are to be at least of 80% of the average selling price of electricity to households in the previous year. The tariffs are established and published by the Energy Regulator. A recent proposal for amendments to the Energy Act (adopted by the Council of Ministers and submitted to the Parliament) proposes that for a 12 years period the entire volume of RES electricity shall be bought at preferential prices. This rule shall be applied for all producers of RES electricity that enters the market till December 31, 2010. The preferential prices for the entire period till 2022 shall be defined in a specific Regulation issued by the Energy Regulator. In addition, a specific Regulation has been passed to define the criteria and rules for certifying the origin of the electricity from RES. The Energy Regulator is the institution responsible of issuing the certificates;</p> <p>The Energy Act and the Grid Codes include provisions regarding access of RES generation plants to the grid as well as operational standards that TSOs and DSOs must follow towards electricity from RES. The wholesale public provider and the public retailers must buy out all the electricity produced from RES at a preferential price;</p>
Croatia	Ministry of Economy and Regulatory Agency have drafted five by-laws which treat related issues in detail and intend to put them in procedure in July 2006 (national	A plan for the implementation of the Directive 2001/77/EC has been drafted by the Ministry of Economy;	<p>There is no national plan setting indicative targets for production of electricity from renewable sources and for reduction of GHG emissions;</p> <p>The feed-in tariff support scheme is put in place for the production of electricity from renewables (art. 26, par. 5 of the Energy Act);</p> <p>There is no institution appointed to certify the energy source from which the electricity was produced;</p>

Table 4 (Continuation)

Renewable energy			
Country	Legislative basis	Plan for the implementation of the 2001/77/EC	Specific characteristics in the sector of renewable sources
	indicative targets, support schemes, criteria for guarantee of origin, rules for administrative procedures, and solutions to grid issues);	A plan for the implementation of the Directive 2003/30/EC has been drafted by the Ministry of Economy;	Specific authorisation procedures applicable to power plants which use renewable sources are put in place (Energy Act and Electricity Act); Grid system issues are covered by the Grid Code which was recently enforced (April 2006); Majority of requests and applications for RES will come from wind energy. The TSO currently conducts extensive system studies related to security of system operation with a high penetration level of intermittent electricity sources such as wind power plants. To be able to maintain system security under such conditions the TSO will publish specific technical requirements for connection and operation of intermittent electricity sources;
The former Yugoslav Republic of Macedonia	The Law on energy (2006) introduces provisions on energy efficiency and renewables (Chapter IX Energy Efficiency and Renewable Energy Resources, arts. 121-123 general, arts. 124-132 energy efficiency, arts. 133-142 renewables);	According to art. 139 of the Law on energy, for promotion of exploitation of RES should be undertaken the following measures: the target percentage and year of including RES in the energy balance, the percentage of participation and dynamic plan for realization of the target percentage, measures and incentives to encourage the use of biofuels in the transport sector, agricultural policies to encourage the availability of biomass, the procedures for issu-	The Government creates the policy for improvement of energy efficiency and for the exploitation of RES. The Energy Agency gives its support to the Ministry in the elaboration and implementation of the Strategy for improvement of energy efficiency and the Strategy for RES exploitation; According to art. 133 of the Law on energy, the Strategy for the exploitation of RES resources defines the aims of RES exploitation and the modalities of achieving these aims, namely the potential of RES, the feasibility for exploitation of the potential of RES, the target volumes and timeline for the consumption of electricity from RES in the energy balance, defining transitional measures for support of exploitation of renewable resources, including preferential tariffs for preferential producers of electricity, and other support mechanisms; According to art. 134 of the Law on energy, upon the proposal of the Ministry, the Government adopts a Program for the implementation of the Strategy for RES exploitation. The Program defines the measures for RES exploitation and contains measures, financial resources, implementation requirements, indicators for achieved results, technical regulations and national standards for energy efficiency, other relevant data, and the entities performing the activities and the delays for realization of envisaged activities;

Table 4 (Continuation)

Renewable energy			
Country	Legislative basis	Plan for the implementation of the 2001/77/EC	Specific characteristics in the sector of renewable sources
		<p>ing and registration of guaranties of origin for electricity produced from RES, the procedure for certification of a preferential producer of electricity, support mechanisms for the use of RE with a duration period of at least four years; implementation requirements, <i>etc</i>;</p>	<p>The measures for utilization of the RES shall be in further details prescribed by the minister competent for the activities that fall within the energy sector; Energy Agency issues and maintains a registry of guaranties of origin for electricity produced from RES and from high-efficiency cogeneration facilities in the Republic of Macedonia and guaranties of origin associated with imports of electricity issued by other authorized national bodies;</p> <p>The Regulatory Commission shall establish preferential tariffs for electricity sold by preferential producers of electricity and producers of electricity from high-efficiency cogeneration facilities;</p>
Montenegro	The Energy Law specifically regulates generation from RES;	<p>Concerned provisions of the Energy Law require that potential investors in power plants using alternative resources should apply for authorization and license;</p> <p>For such projects, the Regulatory Agency sets out simplified procedures and requirements regarding applications for authorizations and licenses;</p> <p>The Energy Law envisages the simplified procedures for realization of the right of access to transmission and distribution networks on non-discriminatory basis;</p>	<p>During March 2005 the Strategy of Energy Efficiency of Montenegro was finalized. The Montenegrin Unit for Energy Efficiency has been organised within the Ministry according to the Energy Efficiency Strategy and related Action Plan for 2005-2006.</p> <p>The Small Hydropower Plant Development Strategy for Montenegro has been adopted by the Government together with the preliminary Action Plan. It is going to become an integral part of the Strategy for Development of the Energy Sector in Montenegro till 2025.</p> <p>Currently, three project studies (solar/wind/biomass) are in a preliminary phase of formulating terms of reference. Upon completion, they will serve as a basis for a strategy for development of renewable sources in Montenegro providing among other targets, support scheme, guarantee of origin ...</p> <p>It is established that power plant of installed capacity below 10 MW using renewable sources is entitled to sell energy in the distribution network. The Ministry sets out methodology, including price setting methodology, for efficient connection to the network, since the document Rules for the Electricity Tariffs issued by the Energy Regulatory Agency is not applicable to small power plants with installed power less than 10 MW;</p>

Table 4 (Continuation)

Country	Renewable energy		
	Legislative basis	Plan for the implementation of the 2001/77/EC	Specific characteristics in the sector of renewable sources
Romania	<p>Romania has an important renewable energy potential, that is only partly used and mainly from hydro sources. In order to promote the development of RES, other than large hydro power plants, the Government of Romania adopted a Renewable Energy Strategy by Government Decision nr. 1535/2004, in which sets the target of 33% power generated/used from RES including large hydro power plants. This will represent 11% share of renewable resources in total primary energy resources, by 2010;</p>	<p>Directive 2001/77/EC for the timeframe 2005-2010, was adopted through the Government Decision 443/2003. As a consequence, the ANRE promoted a number of regulations and legal acts to promote incentives for RES, including:</p> <p>Government Decree 1249/2004 on Guaranty of origin of electricity produced from RES, Government Decrees 1892/2004 and 958/2005 on Promotion of energy generation from RES, and ANRE Order 40/2005 on the Organization and functions of Green Certificates market;</p>	<p>Romania has introduced mandatory quotas (0.7% in 2005, 2.22% in 2006, 3.74% in 2007, 5.26 % in 2008, <i>etc.</i>) of electricity supplied from renewable sources for each supplier and developed a Centralised Market of green certificates operated by OPCOM, since November 2005. Green certificates can also be traded bilaterally between companies. Between November 2005 and February 2006, there were issued to the producers 7183 Green Certificates for 2005 electricity produced from RES eligible to participate in this system. On the centralized green certificates market there were traded between November 2005 and February 2006 (for 2005 year quota) 7241 Green Certificates;</p> <p>In order to prevent excessive prices for green certificates as there are still a small number of generators that received green certificates, a Government Decision 958/2005 was passed to introduce ceiling prices of minimum 24 €/MWh and of maximum 42 €/MWh.</p> <p>The time period for granting licenses to the green producers is shorter than for the other producers and the grid operators are obliged to ensure the transmission/distribution of green electricity;</p>
Serbia	<p>No legislation yet on the Directives for promotion of electricity from RES or on the Directive for biofuels for transport;</p>	<p>See previous column;</p>	<p>See previous columns;</p>

Table 4 (Continuation)

Renewable energy			
Country	Legislative basis	Plan for the implementation of the 2001/77/EC	Specific characteristics in the sector of renewable sources
United Nations Interim Administration Mission in Kosovo	The Energy Strategy and all major energy laws make particular reference to energy efficiency and renewables (see Chapter 6 of the Energy Strategy; Chapter 3 articles 9-14 of the Law on energy and art. 10 of the Law on Electricity in particular). Energy efficiency and protection of environment are specific criteria for granting licenses (art. 30.2 of the Law on Energy Regulator);	The promotion of power generation from RES, and the Regulation for certification of Origin of Electric Power Generated by Renewable Energy Sources is in details dealt with in the Law on Energy and the Law on Electricity;	The Energy Act states that the Ministry of Energy and Mining shall each year establish indicative targets for the consumption of electricity or heat generated from RES or co-generation; The Energy Regulator is the institution responsible of issuing the certificates for origin of electricity produced from renewable energy sources. However, currently there is no tariff determined for renewable energy and no certificates of origin have yet been issued; The Law on Energy has a separate provision, obliging a priority dispatch of electricity produced on the ground of RES (art. 11); The legislation envisages concrete mechanisms for cooperation between the relevant institutions as to promote energy efficiency. This refers both to the cooperation between state institutions (<i>e. g.</i> between the Ministry of Energy and Mining and the Regulator in the process of preparing secondary legislation, but also cooperation with non-governmental organizations – see art. 10 of the Law on Energy);
Turkey	Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (Law No. 5346) enacted on May 18, 2005;		The Electricity Market Licensing Regulation defines the RES scheme and requires generators to obtain a license; Under the 2005 RES Law retailers are obliged to purchase at least 8% of their electricity from RES (not including large hydro). Until 2011 the price to be paid is the average wholesale electricity price which has to be determined annually by the regulator. The Council of Ministers can increase up to 20% this price; The energy regulator is responsible for issuing the guarantees of origin; Biofuels for transport will also be addressed as part of the ongoing legislative efforts in different sub-sectors;
Regional perspective	Legislative basis related to RES is not well developed. Majority of the Contracting Parties do not have action plans on implementation of EU Directive 2001/77/EC. Further work is needed in setting indicative targets for production of electricity from renewable sources and for reduction of GHG emissions, putting support scheme in place for the production of electricity from renewables, appointing institution to certify the energy source from which the electricity is produced, applying specific authorisation procedures applicable to power plants which use renewable sources, and covering grid connection and system operation issues.		

sufficient. For the most part such areas are under special care of the state (*i. e.* underdeveloped, devastated by war, depopulated), on islands or in mountainous regions. In addition, these regions have good renewable energy potential. Since the decentralized energy generation covers a broad range of technologies, including many renewable energy technologies that provide small-scale power at sites close to the users, such concept could be of interest for these locations. This paper identifies the areas in WB where such systems could be applied. Consideration is given to geographical locations as well as possible applications. Wind, hydro, solar photovoltaic (PV), and biomass conversion systems were taken into consideration. Since the RES data for WB region are rather scarce, the intention was to give a survey of the present situation and an estimate of future potential for DEG based on RES.

The islands and coastal area of Adriatic sea (and partly Ionian sea regarding WB region of southern Albania) have very good solar and wind potential. A great number of sunny hours with high irradiation (Croatia >1450 kWh/m², Albania >1500 kWh/m² annually) and average wind velocities above 4-5 m/s represent energy potential that should not be ignored (figs. 1 and 2). The global horizontal irradiation in fig. 1 was compiled using the data from the Joint Research Centre of European Commission [8]. Data are given on the regional basis – NUTS 3 regions (a system of administrative division of countries similar to that of the Nomenclature of Territorial Units for Statistics [9]), established by Eurostat, for the purpose of uniform representation.

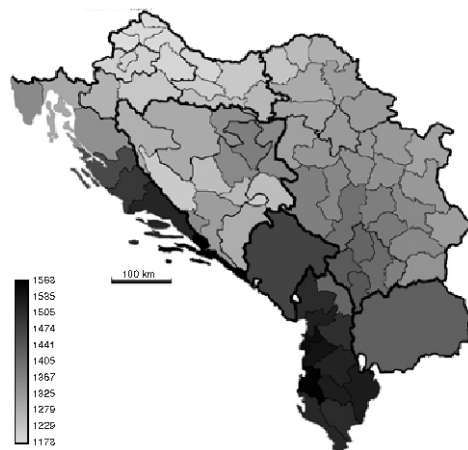


Figure 1. Global horizontal irradiation [kWh/m² per year]

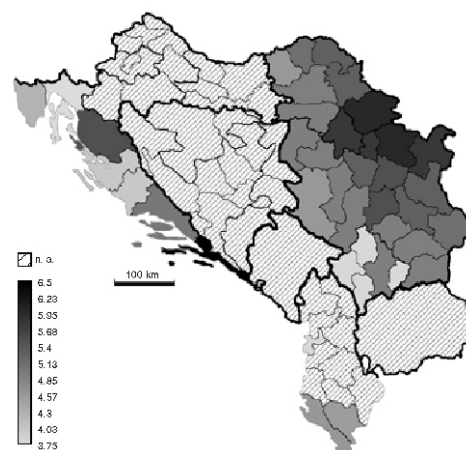


Figure 2. Average annual wind velocity [m/s]

Furthermore, in the mountainous regions of WB there is considerable wind potential as in Bosnia and Herzegovina (Sarajevo area and on the South) or as in Macedonia where there are locations in high mountains which have average annual wind speeds ex-

ceeding 7 m/s [10]. The systematic measurements were not conducted in WB countries, so the wind potential in many countries is not explicitly known (fig. 2, n. a. – not available). That is certainly one of the barriers to wider implementation of wind power production in WB.

Although collected for many decades in almost all WB countries, the data obtained from meteorological stations are incomplete for the investment purposes (*e. g.* they lack data like vertical wind speed profiles). Even knowing wind speed at the macro-level (wind atlas) is not sufficient for potential developers of wind power plants since the on-site data (micro-level) are required. Except for a couple of dozen locations, there are no continuous measurements of wind speed over several years. Therefore, various companies willing to invest in this sector have difficulties to assess the feasibility of the projects.

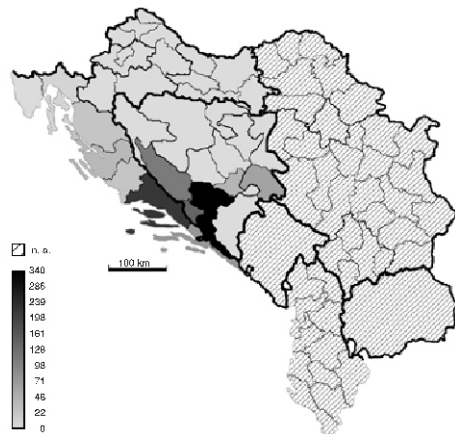


Figure 3. Maximum load capacity of proposed wind facilities [MW]

the information considering all planned and potential RES projects. The data used were obtained from different sources: published literature, relevant ministries and agencies, and where relevant data were not available or obsolete, experts were consulted [13-23].

In some countries the administrative barriers limit the exploitation of all viable wind potential, like in Croatia where the government has banned construction and planning of all new wind power plants (together with quarries, warehouses, factories *etc.*) on locations that are on islands and less than 1000 m from the sea. The projects that had already obtained the location permits prior to that decree are excluded. The act was explained as a measure to protect the Croatian coastal area. That, unfortunately, includes some of the best wind potential locations on Croatian islands and along the Adriatic coast (regions of Southern and Western Croatia).

Apart from electricity production from the large wind farms, there are also other possible applications, *e. g.* the small wind turbines for irrigation in river deltas and on

The map on fig. 3 shows technical potential of wind units for electricity generation. The potential is estimated based on proposed future wind power plant projects, with their capacities totalled per NUTS 3 regions. The load capacity given in the figure represents the maximum capacity, assumed to be solely active power that could be produced continuously throughout a prolonged period of operation under representative climatic conditions [11]. Similarly, the energy capability (*e. g.* figs. 7-9) is the maximum quantity of electrical energy produced under the most favorable conditions. This resource availability takes no account of electricity transmission and distribution constraints.

The maximum load capacity and the maximum potential energy produced (energy capability) were calculated [12] using

lakes or as in the case of Albania where the wind turbines could be used for safeguarding the land from floods [13]. Also, there are plans for hybrid facilities, like a proposed wind farm Stupišće on island of Vis (planned in National energy programme Enwind [14]), which is forethought to supply energy for pumps for irrigation and water desalinization.

Despite good solar potential it is not likely that large solar power plants will be built in following years in WB countries due to high cost of these facilities. With the exception of a certain number of households and other buildings, solar PV systems will be reserved for isolated areas and specific purposes. Potential applications could be: telecommunication base stations, meteorological stations, lighthouses, road signs, public lighting, different autonomous monitoring systems (pollutant emission monitoring, forest fire protection, technical protection of individual facilities *etc.*). It is difficult to estimate the maximum load capacity of potential PV systems because there are no official statistics of their use. The PV potential could be given approximately by the PV power shown in fig. 4. Their future implementation will probably include a large number of units of smaller outputs, whether on grid or off grid applications. The costs of such facilities exceed 20 c€/kWh.

On the other hand, thermal solar systems for hot water production will be used extensively due to their reasonable economy. At the moment however, the main obstacle preventing wider usage of such systems is the lack of legislation that promotes and subsidizes the use of renewable energy systems, contrary to other European countries.

There are also some other examples of RES hybrid systems:

- in B&H where the solar collectors of simpler design (no insulation, with a half-cylindrical reflecting surface) are used in industrial objects, hotels and apartment buildings; they are typically installed in a combination with a wood burning boiler/furnace and they are used for low temperature heating and domestic water heating,
- one of the first PV systems in B&H was installed and put into service as a part of a project financed by the government of Spain; the system has a total power of 0.32 kW and is used as the energy source for the irrigation system in Popovo Polje, located in canton K7 and Republic Srpska,
- hybrid system at the Mechanical Engineering Faculty in Sarajevo; it consists of a solar system (4.2 m² of solar collector area) and a conventional natural gas burner (15 kW), and is used for water heating, and

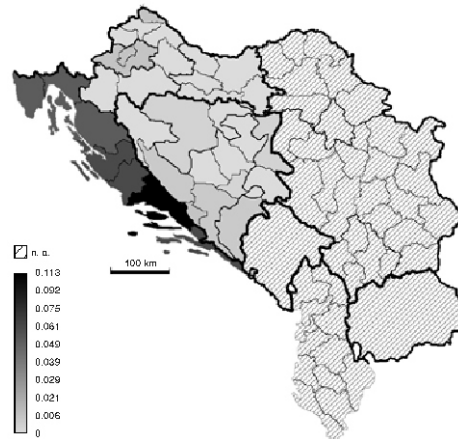


Figure 4. PV power (horizontal) [MWh per year]

- in Albania, a pilot project on exploitation of photovoltaic systems for pumping of irrigation and potable water.

Use of biomass is favorable in the low plains of Pannonia basin. Here agricultural residues such as, sunflower, soybean, rapeseed, and beans (shown in fig. 5) are plentiful*. Fruit residues are available all over WB, while olive residues could be found in the coastal regions. In the mountainous forested regions (and partially in plains), forest residues and wood waste from wood processing industry (fig. 6) could be recovered in large quantities. This biomass could be used for the purpose of district heating and, on a smaller scale, electricity production. Some of the countries already use energy from the biomass *e. g.* Serbia [15]. One of the recent examples of biomass use is the construction of 3 MW furnace (cigarette-type, domestic production) burning soy straw (in forms of jumbo bales, 2 m height, di-

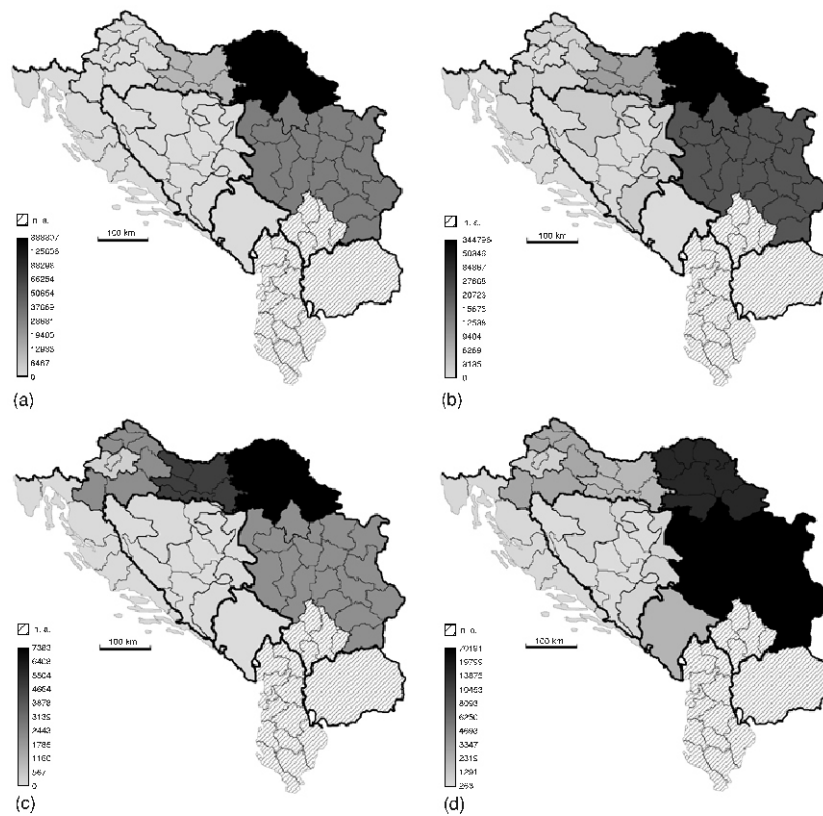


Figure 5. Agricultural biomass potential [t]
(a) sunflower, (b) soybean, (c) rapeseed, (d) beans

* The figures showing usable biomass are calculated based on existing (at the time of evaluation) arable land and do not take into account potential agricultural land, which is not yet developed

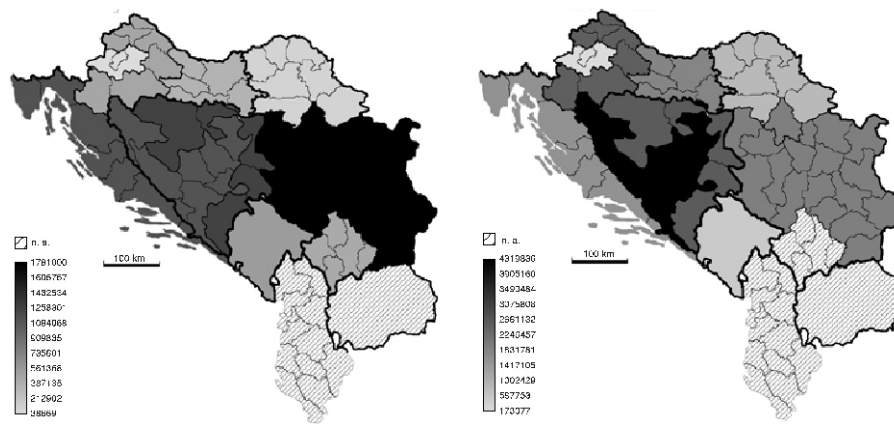


Figure 6. Woody biomass potential
 (a) forest area [ha], (b) annual production of wood
 assortment (logs, firewood, wood residue) [m³]

iameter 1.2 m) commenced in agriculture industry farm PKB-Padinska Skela, near Belgrade, Serbia. The facility will serve for heating of greenhouse.

Energy potential from biomass is considerable and it is expressed as the energy capability (in GWh) given in fig. 7. This represents the maximum electricity that could be produced from the planned and potential biomass co-generations and biogas units. It is estimated that in BiH biomass will be the second most important renewable source of energy after large hydroelectric facilities.

Biomass co-generation facilities have relatively low energy production costs, comparable to those of large hydro and wind power plants. But unlike the wind farms, power production from the biomass has higher social benefits in terms of increased employment of local workforce and additional activities for farmers that will produce raw material.

In addition, the significant energy potential of waste should be mentioned. Waste materials considered here include: municipal solid waste, sewer sludge, landfill gas, solid and liquid manures from livestock farms and abattoirs. Generally, waste recov-

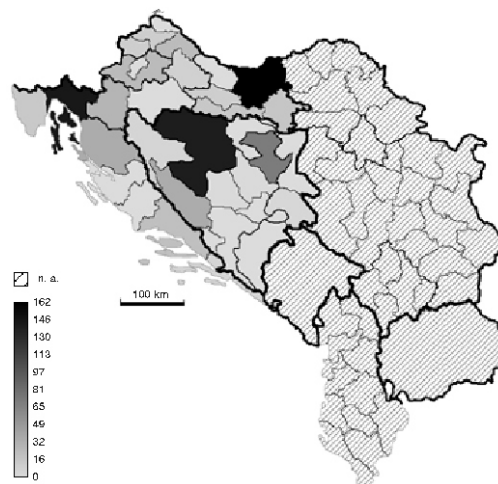


Figure 7. Energy capability of potential biomass facilities [GWh]

ery has been neglected in WB countries and hence waste was almost unused as an energy source. Different WB countries are currently making efforts to establish their waste management systems. Among other things, they anticipate the energy recovery of waste (that part of the waste that cannot be recycled or used in other ways). It can be expected that the importance of this sector will grow in the near future.

Certainly, some negative aspects of biomass and waste combustion, such as air pollution, should be kept in mind. Biomass, although considered as renewable fuel and CO₂ neutral, can cause local air pollution if the products of combustion are not treated adequately. Therefore, a basic requirement when burning biomass and solid waste is to ensure appropriate flue gas cleaning and control systems, which will satisfy limiting values of emissions prescribed by law. An especially sensitive issue in solid waste combustion is the emission of toxic organic substances like dioxins and furans that should be monitored very carefully.

Hydro potential is traditionally the most exploited renewable energy resource in all WB countries. Some countries, *e. g.* Albania, are even overdependent on hydro power (98% of total electricity production), which could result, in poor hydrological conditions, in shortages.

The large hydro power plants, although belonging to centralized power generation, are included in this analysis for the purpose of cost comparison. It is not surprising that the cost of electricity produced from the big hydro power plants is the lowest of all RES. The same however, does not stand for the small hydro power plants. The small hydro power plants are of sizes less than 10 MW. Depending on the specific case they could exhibit substantial costs.

One part of hydro potential suitable for large hydro power plants is permanently lost due to urban, environmental, and economic limits, or due to significant tourist potential of rivers in WB region.

Some of the WB countries still have a certain number of undeveloped sites where large projects could fit in. In most cases the energy capability of potential (large) hydro power plants refers to an increase of capacity/capability of already existing facilities (additional or improved units) and only at several locations completely new large hydro power plants will be built. Figures 8 and 9 show energy capabilities of potential large and small hydro power plants. In some countries the construction of new larger hydro power plants is meeting fierce opposition of local communities and environmental non-governmental organizations. For example, even small hydro power plant projects in Croatia are con-

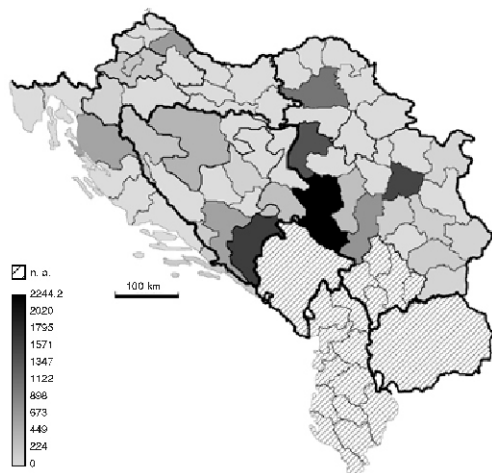


Figure 8. Energy capability of potential large hydro power plants [GWh]

fronted with strong public resistance due to increased environmental consciousness. Therefore, the list that defines the quite significant hydro potential of small hydro power plants, shown in fig. 9, will have to be revised.

Conclusions

The removal of geographical constraints to the delivery of power (recent reconnection of South-East Europe into a single UCTE system), the gradual liberalization of energy markets, the privatization of the utility companies and new environmental legislation introduce new factors into the conventional power systems of WB countries. Thus, security of energy supply, climate change mitigation and economic competitiveness (electricity and gas market deregulation) open a possibility for a novel concept of dispersed power generation that could easily coexist with the conventional centralised systems in future. The RES technologies, whether they exploit wind, hydro or solar power, geothermal heat, biomass and waste materials, have many benefits like energy resource diversification, decreased fossil fuel use, and reduced per unit GHG emissions. However, construction and utilization of dispersed energy sources should not diminish the significance of the conventional sources to maintain the integrity of power system. In line with numerous advantages of decentralized production, some of DEG-RES systems (wind, solar, biomass CHP) are characterized by their limitation in providing ancillary services as well as following the daily consumption curve. Availability of wind and solar PV conversion systems production depends on the meteorological conditions, whereas electricity production in biomass co-generation facilities is determined by the local heat requirements. As a result of the increased share of dispersed sources, an increased reserve capacity will be required.

An intermittent nature of renewable sources can be partially mitigated by applying different energy storage systems or energy carriers such as high capacity batteries (new technologies and electrolytes, flow batteries) up to several tens of MWh, capacitors, flywheels, compressed air systems, reversible hydro systems, and hydrogen (fuel cells), which could provide power when it is needed.

The DEG based on RES in WB will find its niche easier for the users that will produce electricity for their own needs and for the users located in remote rural areas where there is no electricity network or the network capacity is insufficient (off-grid applications). The users (most likely small companies) that produce heat and/or power for

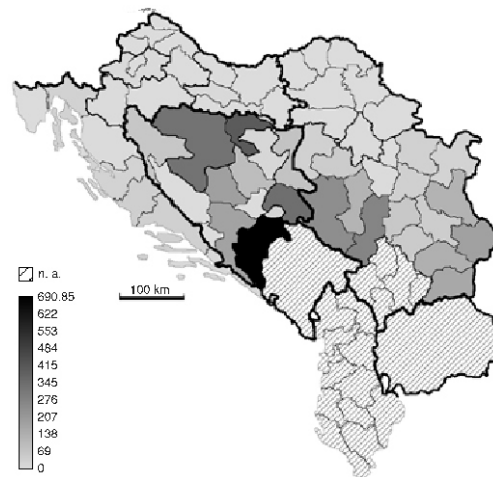


Figure 9. Energy capability of potential small hydro power plants [GWh]

their own use (like agriculture, wood and food processing industry) could thus control and reduce their costs for energy and achieve some sort of energy independence (*e. g.* applying co-generation plant that uses biomass). They could also be grid-connected, islanded (off-grid) or embedded (in which case the extra generation could be sold to retailer).

Examples of potential application of DEG based on RES in WB could include:

- hotels and apartment houses, restaurants, auto-camps, nautical marinas, sports and entertainment centers, chalets, also some facilities in rural and hunting tourism – in general all tourist facilities that are situated in remote isolated areas on islands and in mountains where there is no possibility of network connection or it would be too expensive to connect or is not permitted by environmental laws (*e. g.* in national parks and nature reserves),
- cooling facilities for temporary storage of fish, meat *etc.*, field ambulances (for electrical medical appliances and cooling of medicines), electrical fences for livestock ranching, autonomous electrical livestock/game feeders and water-troughs, for lighting and operation of agricultural facilities, hatcheries,
- irrigation in deltas of rivers, water desalination on islands,
- telecommunication (base) stations, meteorological stations, lighthouses, road signs, public lighting, different autonomous monitoring systems (pollutant emission monitoring, forest fire protection, technical protection of individual facilities *etc.*),
- households (permanent and weekend settlements) in isolated and rural areas (mountainous and coastal/island regions),
- saw mills situated near small rivers, in which power from the small hydro power plants could be used, and
- hybrid combination of solar systems or wind turbines with liquefied petrol gas or diesel aggregates could help solve the problem of energy infrastructure on islands and other remote locations. Furthermore, that could start development of traditional island activities with the engagement of local resources and workforce, which could, in turn, reduce depopulation of islands.

If external costs connected with global climate change and local pollution are included in the cost of electricity from conventional sources, which could reach up to 10 c€/kWh (for coal power plants, externalities included), then the production of electricity from renewable sources becomes quite attractive. The utilization of these resources could also help the WB countries meet their Kyoto Protocol requirements, with the condition that the adequate incentives are provided.

Acknowledgments

This work was carried out as a part of the ADEG “Advanced Decentralised Energy Generation Systems in Western Balkans” project, financed by the European Commission through INCO program of 6th FRAMEWORK PROGRAM [12].

References

- [1] ***, Benchmarking Report on SEE TSOs Status of Reform for 3rd Athens Forum, SETSO Task Force, Sofia, 2003
- [2] ***, Third Benchmarking Report on the Implementation of the Internal Electricity and Gas Market, Commission of the European Communities, Brussels, 2004
- [3] ***, CARDS Project 2005 Facilitating and Implementing the Energy Community in South East Europe, Energy Community Report on Compliance with the Electricity Benchmarks, 2006, www.energy-community.org/pls/portal/docs/69826.PDF
- [4] ***, Energy Community – Country Reports, 2006
- [5] Dizdarević, N., Renewables in the Context of the Treaty Establishing the Energy Community, Joint EURELECTRIC-VEÖ Central & East-European Regional Conference, Renewable Energy in Central & Eastern Europe: Challenges and Policy Responses, Vienna, 2006
- [6] ***, The National Strategy of Energy of Albania, Ministry of Industry and Energy, National Agency of Energy, World Bank, 2003
- [7] Donevski, A., Survey of the Energy Situation in Macedonia, Faculty of Technical Sciences, University St. Clement Ohridski, Bitola, Macedonia, 2000 (Published at International Workshop and Round Table Discussion on the Energy Future of Bosnia and Herzegovina, 2000, Mechanical Engineering Faculty, Sarajevo, Bosnia and Herzegovina)
- [8] European Commission, DG – Joint Research Centre, Institute for Environment and Sustainability, Renewable Energies Unit, 2002, <http://re.jrc.cec.eu.int/pvgis/regionframe.php>
- [9] ***, Hierarchical List of the Nomenclature of Territorial Units for Statistics – NUTS and the Statistical Regions of Europe, Eurostat, 2005, http://ec.europa.eu/comm/eurostat/ramon/nuts/codelist_en.cfm?list=cec
- [10] ***, Renewable Energy Country Profile – FYRO Macedonia, NV Consultants, Primary Country Consultant, Interwind, Black & Veatch, European Bank for Reconstruction and Development, 2002
- [11] ***, Union for the Co-ordination of Transmission of Electricity (UCTE), 2004, <http://www.ucte.org>
- [12] Schneider, D. R., Grubor, B., Lekić, A., *et al.*, Map of DEG Potential in WB, Deliverable 1, Advanced Decentralised Energy Generation Systems in Western Balkans (ADEG), 2005, Zagreb, <http://powerlab.fsb.hr/adeg>
- [13] ***, Renewable Energy Country Profile, ARGES Enerji Sistemleri San. Ve Tic. A. S., Renewable Energy Resource Assessment, European Bank for Reconstruction and Development, 2002
- [14] Horvath, L., *et al.*, ENWIND – Wind Energy Utilisation Program (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 1998
- [15] ***, Energy Potential and Characteristics of Biomass Waste and Technology for its Application and Energy Usage in Serbia, Project NP EE611-113A, Ministry of Science and Technology of the Republic of Serbia, Belgrade, 2003
- [16] Hrastnik, B., *et al.*, SUNEN – Solar Energy Utilisation Program (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 1998
- [17] Hrastnik, B., *et al.*, SUNEN – Solar Energy Utilisation Program – New Advances and Implementation (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 2001
- [18] Horvath, L., *et al.*, ENWIND – Wind Energy Utilization Program (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 1998
- [19] Horvath, L., *et al.*, ENWIND – Wind Energy Utilization Program – New Advances and Implementation (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 2001
- [20] Matic, Z., Solar Radiation Atlas for the Area of the Republic of Croatia, *Book of abstract*, 1st International Forum of the Renewable Energy Sources, Zagreb, Energetics of Marketing, Zagreb, 2004, p. 16

- [21] ***, European Commission, DG – Joint Research Centre, Institute for Environment and Sustainability, Renewable Energies Unit, 2002, <http://re.jrc.cec.eu.int/pvgis/regionframe.php>
- [22] Domac, J., *et al.*, BIOEN – Biomass and Waste (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 1998
- [23] Bašić, H., *et al.*, MAHE – Small Hydroelectric Power Plants Construction Program (National Energy Program), Energy Institute Hrvoje Požar, Zagreb, 1998

Authors' addresses:

D. R. Schneider, N. Duić, Ž. Bogdan, M. Ban
Faculty of Mechanical Engineering and Naval Architecture,
University of Zagreb
5, I. Lučića, HR-10000 Zagreb, Croatia

I. Raguzin
Ministry of Economy, Labour and Entrepreneurship
78, Ulica grada Vukovara, HR-10000 Zagreb, Croatia

*B. Grubor, P. Stefanović, D. Dakić, B. Repić, Ž. Stevanović, A. Žbogar,
M. Studović, S. Nemoda, N. Oka, D. Djurović, N. Kadić, V. Bakić,
S. Belošević, A. Erić, R. Mladenović, M. Paprika*
VINČA Institute of Nuclear Sciences
P. O. Box 522, 11001 Belgrade, Serbia

*N. Delalić, A. Lekić, R. Bajramović, A. Teskeredžić, I. Smajević,
E. Džaferović, F. Begić, H. Lulić, S. Metović, S. Petrović,
A. Djugum, Dž. Kadrić, N. Hodžić, F. Kulić, A. Kazagić, A. Gafić*
Mechanical Engineering Faculty, University of Sarajevo
9, Vilsonovo šetalište, 71000 Sarajevo, Bosnia and Herzegovina

Corresponding author D. R. Schneider
E-mail: daniel.schneider@fsb.hr

Paper submitted: July 21, 2006
Paper revised: March 31, 2007
Paper accepted: April 10, 2007